REMARKS

Applicants submit the present *Amendment* in response to the Office Action dated April 18, 2007 (the "Office Action"). Applicants have cancelled Claim 1 and non-elected Claims 15-33, rewritten Claims 4 and 13 into independent form (and further amended Claim 4), revised the dependencies of Claims 2, 9-10 and 14, and added new Claims 34-47 (each of which is drawn to the elected species). In light of these claim amendments, as well as the arguments presented below, Applicants respectfully submit that all of the pending claims are now in condition for allowance.

I. The Claim Rejections

Claims 1-3, 9-12 and 14 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent Publication No. 2003/0017669 to Kiyotoshi et al. ("Kiyotoshi") in view of U.S. Patent No. 6,756,261 to Hong ("Hong"). Claims 4-6 and 7-8 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over the combination of Kiyotoshi, Hong and U.S. Patent Publication No. 2005/0020060 to Aaltonen et al. ("Aaltonen"). Finally, Claim 13 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over the combination of Kiyotoshi, Hong and U.S. Patent No. 6,656,784 to Pakr ("Pakr"). Applicants have cancelled Claim 1. Applicants respectfully traverse the rejections of the remaining claims for the reasons explained below.

II. Independent Claim 4 is Patentable Over Kiyotoshi and Hong

As discussed above, Claim 4 has been rewritten into independent form and further amended to recite one of the two recitations of Claim 6. As amended, independent Claim 4 recites:

> 4. A method of fabricating an electrode for a microelectronic device, the method comprising:
>
> forming a ruthenium seed layer using atomic layer deposition on a semiconductor substrate;
>
> forming a main ruthenium layer on the ruthenium seed layer; and
>
> patterning the main ruthenium layer and the ruthenium seed layer to form the electrode;

wherein forming the ruthenium seed layer using atomic layer deposition comprises at least one cycle of:

injecting a ruthenium source into a chamber containing the semiconductor substrate; then

injecting an oxygen-containing gas into the chamber containing the semiconductor substrate; and then

injecting a hydrogen-containing gas into the chamber containing the semiconductor substrate, wherein the hydrogen-containing gas comprises molecular hydrogen (H_2) and/or ammonia (NH_3).

The Office Action states that Kiyotoshi discloses all of the recitations of the method of Claim 1 except for (1) forming the ruthenium seed layer using atomic layer deposition or (2) the specific details of the operations for forming the ruthenium seed layer. (Office Action at 2 and 5-7). The Office Action further states that Hong discloses forming a ruthenium layer via atomic layer deposition, and that Aaltonen discloses the operations for forming the ruthenium seed layer that are recited in Claim 4. (*Id.*). Finally, the Office Action states that it would have been obvious to modify the method of Kiyotoshi to form the ruthenium seed layer by atomic layer deposition in order to "control the composition easily with excellent step coverage" and that it would have been obvious to modify the method of Kiyotoshi, as modified by Hong, to include the operations of Aaltonen "in order to control the surface reactions of the precursor chemicals, or avoid gas phase reactions." (Office Action at 2, 6-7). Applicants respectfully submit, however, that (1) the combination of Kiyotoshi, Hong and Aaltonen does not disclose all of the recitations of the method of Claim 4 and (2) that one of ordinary skill in the art would not have combined the cited references in the manner suggested in the Office Action.

A. The Cited Art Fails to Disclose all of the Recitations of Claim 4

As an initial matter, Applicants respectfully submit that the combination of Kiyotoshi, Hong and Aaltonen fails to disclose at least two of the recitations of Claim 4. In particular, none of the cited references disclose (1) forming the ruthenium seed layer by at least one cycle of "injecting an oxygen-containing gas into the chamber containing the semiconductor substrate; and then injecting a hydrogen-containing gas into the chamber containing the

semiconductor substrate" or (2) that "the hydrogen-containing gas comprises molecular hydrogen (H_2) and/or ammonia (NH_3)." While the Office Action cites to Aaltonen as disclosing each of these recitations of Claim 4, what the cited portions of Aaltonen disclose are "pulsing a vaporized precursor of the noble metal into the reaction chamber" and then "providing a pulse of oxygen containing gas onto the substrate." (Aaltonen at ¶¶ 0035-0041). As such, Aaltonen at most discloses injecting one of an oxygen-containing gas **or** a hydrogen-containing gas into the chamber, not first injecting an oxygen-containing gas **and then** injecting a hydrogen-containing gas. More importantly, Aaltonen teaches that the oxygen containing gas that is pulsed into the chamber is a gas such as H_2O_2 or N_2O or hydrogen peroxide. (Aaltonen at ¶¶ 0018, 0056). As such, Aaltonen clearly does not disclose that "the hydrogen-containing gas comprises molecular hydrogen (H_2) and/or ammonia (NH_3)" as is recited in Claim 4. Thus, as the cited references fail to disclose at least two of the recitations of Claim 4, the rejection of Claim 4 should be withdrawn.

B. Kweon and Molla Would Not Be Combined in the Manner Suggested

Applicants also respectfully submit that one of ordinary skill in the art would not have been motivated to combine the cited references in the manner suggested in the pending rejections. For example, as noted above, the Office Action states that it would have been obvious to modify the method of Kiyotoshi to form the ruthenium seed layer using the atomic layer deposition process of Hong in order to "control the composition easily with excellent step coverage." (Office Action at 2). However, the portion of Hong (Col. 3, lines 28-33) cited as providing this motivation is actually **discussing the formation of an STO layer as opposed to a ruthenium layer**. In particular, the cited portion of Hong states that after the bottom electrode is formed of a noble metal such as Pt, Ru or Ir, "an STO layer is formed at a thickness ranging from 5 nm to 10 nm using the atomic layer deposition process which can control the composition easily with excellent step coverage." (Hong at Col. 3, lines 28-33). The fact that Hong is referring to the formation of the STO layer, as opposed to the noble metal layer, is also apparent from the discussion on the Detailed Description portion of the application, which describes in detail how the component of the STO layer may be easily

controlled. (*See* Aaltonen at Col. 4, lines 51-65).

Moreover, the portion of Kiyotoshi cited in support of the pending rejections is a description of the background art. (*See* Kiyotoshi at ¶¶ 0014-0019). Kiyotoshi goes on to explain in detail the problems with the prior art method. (*See* Kiyotoshi at ¶¶ 0020-0024). Accordingly, Kiyotoshi goes on to describe a different method that overcomes these problems with the background art method. (*See* Kiyotoshi at Detailed Description of the Invention). Applicants respectfully submit that one of skill in the art would look to using the methods described in the Detailed Description of the Invention section of Kiyotoshi as opposed to practicing modified versions of the methods that Kiyotoshi expressly teaches suffer from a number of problems. Accordingly, Applicants respectfully submit that the rejection of Claim 4 should independently be withdrawn because one of skill in the art would not have combined the references in the manner suggested in the pending rejections.

III. Dependent Claims 5-8 and 14 are Patentable Over the Cited Art

Claims 5-8 and 14 each depend from Claim 4. Accordingly, these claims are each patentable over the cited art for at least the same reasons, discussed above, that Claim 4 is patentable over the cited art. Moreover, Applicants submit that at least Claims 6, 7 and 14 are independently patentable over the cited art for the following reasons.

Claim 6 recites that "the oxygen-containing gas comprises an O_2 gas, an O_3 gas, and/or an H_2O gas." The Office Action states that Aaltonen discloses using H_2O_2 to form the ruthenium layer. (Office Action at 6). While H_2O_2 is an oxygen-containing gas, it clearly is **not** O_2, O_3, or H_2O. Accordingly, the cited references fail to render the subject matter or Claim 6 obvious for at least this additional reason.

Claim 7 recites that "at least one of the oxygen-containing gas or the hydrogen-containing gas is supplied in a plasma phase." While the Office Action cites to paragraph 0127 of Kiyotoshi as disclosing this recitation, the cited paragraph of Kiyotoshi refers to **the deposition of a silicon oxide film** that relates to an embodiment of Kiyotoshi that is not cited in support of the pending rejections. As such, the reference to plasma CVD has nothing to do with the formation of a ruthenium seed layer, has nothing to do with the portion of Kiyotoshi

that is cited in the pending rejections, and has nothing to do with growing a layer by atomic layer deposition. Accordingly, Claim 7 is independently patentable over the cited art for these additional reasons.

Claim 14 recites that "the ruthenium seed layer has an oxygen concentration of less than 5%." The Office Action takes the position that the specification contains no disclosure that such an oxygen concentration is a critical dimension or that any unexpected results arise therefrom. However, the specification does in fact disclose that if the ruthenium layer tends to have a high concentration of oxygen, then during subsequent thermal processing steps the oxygen atoms in the ruthenium layer may diffuse into, and thereby oxidize, a storage node contact plug or other layers of the semiconductor device, leading to an undesirable increase in the contact resistance of the plug. (Specification at 2 and 8). In fact, FIGS. 1 and 4 of the present application show how the methods of the present invention may provide low oxygen contact ruthenium layers that may facilitate reducing and/or minimizing such an increase in the contact resistance of the storage node plug. Nothing in either Kweon or Molla recognizes the potential for oxygen atoms from a ruthenium layer to diffuse into the contact plug. As such, Applicants respectfully submit that providing a ruthenium seed layer with an oxygen content of less than 5% is not suggested by the prior art, and provides an independent basis for concluding that Claim 14 is patentable over the cited art.

Accordingly, for the above reasons, Applicants submit that Claims 5-8 and 14 are also patentable over the cited art.

IV. Independent Claim 13 is Patentable Over Kiyotoshi and Hong

As discussed above, Claim 13 has been rewritten into independent form. As amended, independent Claim 13 recites:

> 13. A method of fabricating an electrode for a microelectronic device, the method comprising:
>
> forming a ruthenium seed layer using atomic layer deposition on a semiconductor substrate;
>
> forming a main ruthenium layer on the ruthenium seed layer; and
>
> patterning the main ruthenium layer and the ruthenium seed layer to form the

electrode;

wherein the main ruthenium layer is formed using chemical vapor deposition.

The Office Action states that the combination of Kiyotoshi and Hong disclose all but the last recitation of Claim 13, and that Pakr at Col. 5, lines 15-20 discloses this recitation. (Office Action at 8). The Office Action further states that it would have been obvious to modify the method of Kiyotoshi, as modified by Hong, to form the main ruthenium layer using chemical vapor deposition "for producing a high-quality depositing layer." (*Id.*). Applicants respectfully submit, however, that the prior art does not fairly suggest modifying Kiyotoshi to use atomic layer deposition for the seed layer and further modifying Kiyotoshi to use chemical vapor deposition for the main ruthenium layer. Instead, Hong and Pakr merely describe the use of atomic layer deposition and chemical vapor deposition methods as methods that are used to form certain layers. Applicants respectfully submit that the rejection of Claim 13 has used Applicants present disclosure as a road map, and that the only motivation to modify Kiyotoshi in the specific manner suggested in the pending rejections is the teachings of the present disclosure. The rejections do not even attempt to explain why one of skill in the art would turn to the Hong reference to decide to replace the sputtering method used in Kiyotoshi in forming the seed layer with atomic layer deposition and then turn instead to the Pakr reference to replace the electroplating method used in Kiyotoshi to form the main layer with chemical vapor deposition. Applicants also submit that the rationale provided above as to why one of skill in the art would not combine Kiyotoshi, Hong and Aaltonen apply equally well to the combination of Kiyotoshi, Hong and Pakr that is used to reject Claim 13. According, the rejection of Claim 13 should be withdrawn for at least each of the above reasons.

V. Dependent Claims 2-3 and 9-12 are Patentable Over the Cited Art

Claims 2-3 and 9-12 each depend from Claim 13. Accordingly, these claims are each patentable over the cited art for at least the same reasons, discussed above, that Claim 13 is patentable over the cited art. Moreover, Applicants submit that at least Claims 11 and 12 are independently patentable over the cited art for the following reasons.

Claim 11 recites that "the dielectric layer comprises a tantalum oxide layer." The Office Action concedes that the cited references do not disclose a tantalum oxide dielectric layer, but argues that it would have been obvious to one of skill in the art to use such a dielectric layer. (Office Action at 4). Applicants respectfully submit, however, that there has been no showing that it would have been obvious to take the method of Kiyotoshi, to then modify that method to use the atomic layer deposition for one layer, further modify that method to use chemical vapor deposition for the formation of another layer, and then yet again further modify that method to replace the dielectric layer of Kiyotoshi with a tantalum oxide dielectric layer. Accordingly, Claim 11 is independently patentable over the cited art.

Claim 12 recites that forming the upper electrode comprises:

> forming a second ruthenium seed layer using atomic layer deposition on the dielectric layer; and
>
> forming a second main ruthenium layer on the second ruthenium seed layer.

The Office Action states that Fig. 9C of Kiyotoshi discloses the recitations of Claim 12. However, Applicants respectfully submit that Fig. 9C of Kiyotoshi discloses only the formation of a first seed layer and a first main layer, and clearly does not disclose the formation of both first and second seed layers and first and second main layers. This is confirmed by the fact that the pending rejections cite to the same layers of Fig. 9C as comprising the first and second seed layers, and as comprising the first and second main layers. (*See* Office Action at 2 and 4). Accordingly, the rejection of Claim 12 should also be withdrawn for at least this additional reason.

VI. New Claims 34-45

Applicants have added new Claims 34-45, which Applicants respectfully submit are patentable over the cited art.

VII. Conclusion

For the above reasons, Applicants respectfully submit that the present application is in condition for allowance, which is respectfully requested.

Respectfully submitted,

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